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Forest Service

Forestry Research West

December 1998

A report for land managers on recent developments in forestry research at the three western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

In This Issue

Cover

Each year, more and more people move into the wildland/urban interface. Throughout much of the western United States, this means homes and cabins admidst ponderosa pine forests. New research out of the Rocky Mountain Research Station sheds light on thinning prescriptions that can not only reduce fire hazard, but improve aesthetics and provide revenue. Details begin on page 7.

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Looking Ahead as HJA Turns 50

by Steve Wilent,
for the Pacific Northwest Research Station

The H.J. Andrews Experimental Forest (HJA) turned 50 this year, and nearly 300 people gathered at the forest's headquarters in August 1998 to celebrate. Among the guests were current and former researchers as well as representatives of the Pacific Northwest Research Station, Willamette National Forest, Oregon State University, and the National Science Foundation (NSF), all of which administer or provide support to the HJA.

"The Andrews" consists of 16,000 acres in the Willamette National Forest's Blue River Ranger District about 50 miles east of Eugene, Oregon. The forest, originally called the Blue River Experimental Forest, was renamed in 1953 in honor of Horace Justin Andrews,

In 1957, little was known about the ecological value of old-growth forests. Research at the Andrews helped to change that.

Regional Forester of the Pacific Northwest Region. Andrews, a proponent of forest research who played a key role in establishing the experimental forest, died in an automobile accident in Washington, DC, in 1951.

The day-long event focused on honoring "a legacy of cooperative science and management" and reexamining the results of the many forest-ecosystem research projects carried out in the forest since 1948. Art McKee, the Director of the HJA, says research from the Andrews' has produced more than new knowledge about forest ecosystems: it has led to changes in forest-management policy and practice that have provided substantial benefits to society. For instance, although studies of log decomposition might at first seem mildly interesting at best, McKee says HJA research by Oregon State University forest ecologist Mark Harmon and others have saved taxpayers millions of dollars. The studies showed that downed logs and standing dead trees have important functions in forest ecosystems. This knowledge led forest managers in the mid-1980s to stop requiring loggers to yard and pile unmerchantable woody debris at timber harvest sites.

"The literature showed that the piling of unusable material is counterproductive," says McKee. "So the Willamette National Forest changed its policy and left the material in the woods instead of removing it. That saved several million dollars on this one forest. And if you multiply that by all of the west-side forests, which shortly thereafter stopped this practice, then many more millions of dollars per year were sent to the national treasury."

Other HJA research on the value of coarse woody debris in streams helped bring about changes in Forest Service policy and revisions of the Oregon Forest Practices Act that reversed long-standing rules requiring debris to be removed from streams.

"This benefits stream productivity, improves habitats for a variety of species, and increases carrying capacity," says McKee. "It increases the efficiency by which energy travels up the food chain, by keeping organic material in the stream from just washing away."

The Andrews' "stream team" research played an important role in establishing programs nationwide to get woody debris back into streams. Some streams in New England, for instance, have been without natural debris for centuries. McKee says trees there are now grown in riparian areas specifically to provide natural debris, and in some cases logs are placed into streams to quickly reintroduce debris structures.

Researchers at the HJA also look beyond the United States to cooperative exchanges of information with scientists in other parts of the world. One current venture involves the St. Petersburg Forestry Academy, one of Europe's oldest forestry universities, which is studying changes in carbon stores on a landscape scale. The two institutions are working to compare carbon levels in northwestern Russia with levels here in the Pacific Northwest.

"We're all very concerned about carbon dioxide, because it's a greenhouse gas," says McKee. "There's a chance that changes in forest practices could help ameliorate the effects of the increasing consumption of fossil fuels by humans."

Horace Justin Andrews, Regional Forester for Washington and Oregon during the late 1940's, was instrumental in establishing the experimental forest that bears his name.

Other international ties include work with researchers from Chile on using forest-management techniques developed at the HJA in that country's forests, and collaboration with Taiwanese researchers to examine the effects of air pollution on nutrient cycling. A team of scientists from Sweden will visit the Andrews this fall to study the distribution of moss species on different microhabitats.

Researching History

The HJA may be 50 years old, but the history of the forest itself goes back much further. Max Geier, an associate professor and chair of the History Department at Western Oregon University in Monmouth, is writing a book on the history of the HJA. Geier says that in 1948, the Andrews was an old-growth forest largely untouched by humans. Forest Service documents written in the late 1940s outlining the establishment of the research site referred to the forest as "virgin" and "untouched." One 1948 memo reported that "there are no roads whatsoever in the area at present" and said that a legal description could not be given because the area had not yet been surveyed.

Nonetheless, the Forest Service envisioned making "large-scale experimental cuttings" of 15 to 20 million board feet per year and to carry out commercial-scale "tests of logging methods and techniques." The planners also proposed studying the forests' influence on streamflow, runoff, snow melt, and other hydrological processes.

"The intent was that this experimental forest be logged," says Geier. "The purpose was to demonstrate that clearcuts were the most efficient way to use the resource."

The research program at the Andrews has grown and evolved over the years into a multidisciplinary program of research that focuses on virtually every known element of the ecosystem.

Jerry Franklin, a forest ecology professor at the University of Washington, began working at the Andrews as a student trainee in 1957. As director of the forest from 1975 to 1986, he has seen several shifts in the focus of HJA research.

"In 1957, we knew nothing about old-growth forests, except how to cut them," he says. "If you asked somebody whether they have any special ecological value, the answer would have been 'no.'

"In fact," he continues, "there was a proposal in the early 1960s to shut down the Andrews. They said, 'We don't need it anymore. We know all we need to know.' But there were a few of us who thought that the potential of this property was extraordinary."

Visitors to the Andrews include educators from high schools and universities, as well as research scientists from all over the world.

Franklin and other HJA researchers, with the support of local Forest Service administrators, worked to attract new research projects and began looking at the effects of harvesting old-growth forests on water quality, sedimentation, and nutrients in streams. In the 1970s, as the HJA took part in, and gained funding from, the United Nations' Man and the Biosphere Program, the direction shifted to examining entire old-growth forest and stream ecosystems. By the 1980s, the researchers had more stable funding provided by the Long-Term Ecological Research (LTER) Program, and they widened their focus to study the forest on a landscape scale, including silviculture, wildlife, and even the human communities in and around the forest. The LTER program is sponsored by the National Science Foundation, which supports ecological studies at 20 sites in the United States and Puerto Rico and two sites in Antarctica.

Franklin and other researchers who worked at the HJA in the 1960s and 1970s remember living in dilapidated house trailers and working without adequate facilities. Some referred to the HJA headquarters as the "ghetto in the meadow," but they reminisce about those days with a perverse sort of pride.

Congressional appropriations and LTER program funds made possible the construction of several new buildings, including dormitories for visiting scientists and students. A 5,000-square-foot building with a meeting room, laboratory-classroom, and offices opened earlier this year, and a new cafeteria and laundry are slated to replace the existing facilities, now housed in trailers, by next year.

Cooperative Spirit

With a modernized headquarters and continued LTER funding, the dozens of scientists and researchers who work at the HJA will continue to work together to address the prime HJA directive: to determine how land use, natural disturbances, and climatic change affect three key ecosystem properties: carbon dynamics, biodiversity, and hydrology. At the same time, with the addition of the laboratory and classroom, HJA staff will increase its emphasis on education.

"This is a place where scientists, managers, members of the public, policymakers, and educators all come together to generate knowledge, to learn, to build a better understanding of the issues," says Lynn Burdette, USDA FS Blue River District Ranger. "This legacy of cooperation and learning has been instrumental in the success of the HJA, its people, and its programs."

Fred Swanson, HJA research team leader, says the spirit of cooperation is made possible by two factors. One, the HJA's focus on watersheds, naturally brings scientists from many disciplines together to collectively examine large-scale problems affecting many parts of society. Second, this diverse community of scientists has been working together for a common goal.

"The scientists who work at this site have been willing to interpret the science to other people," says Swanson. "And that's what makes the Andrews so unique. Had they not been willing to interpret the science in terms of the issues of the day, then the issues would be driven by political agendas, by special interests, and by what happens to be in the newspaper."

Director McKee speaks with enthusiasm about the future of the HJA and the ability of the HJA scientific community to face new challenges. "The Andrews is noted for and takes pride in its long-term research programs," he says. "The strength of such programs resides in the awareness of the need to change: to reevaluate, view old studies and data sets with new perspectives, and pursue new leads."

For More Information

To learn more about the HJA, visit its web site at http://www.fsl.orst.edu/lterhome.html. Contact Art McKee at (541) 750-7350 or by e-mail at mckee@fsl.orst.edu. Contact Fred Swanson at (541) 750-7355 or fswanson/r6pnw_corvallis@fs.fed.us. Write to the HJA at: P.O. Box 300, Blue River, OR 97413; or call (541) 822-6300.

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Thinning Ponderosa Pine in the Wildland/Urban Interface

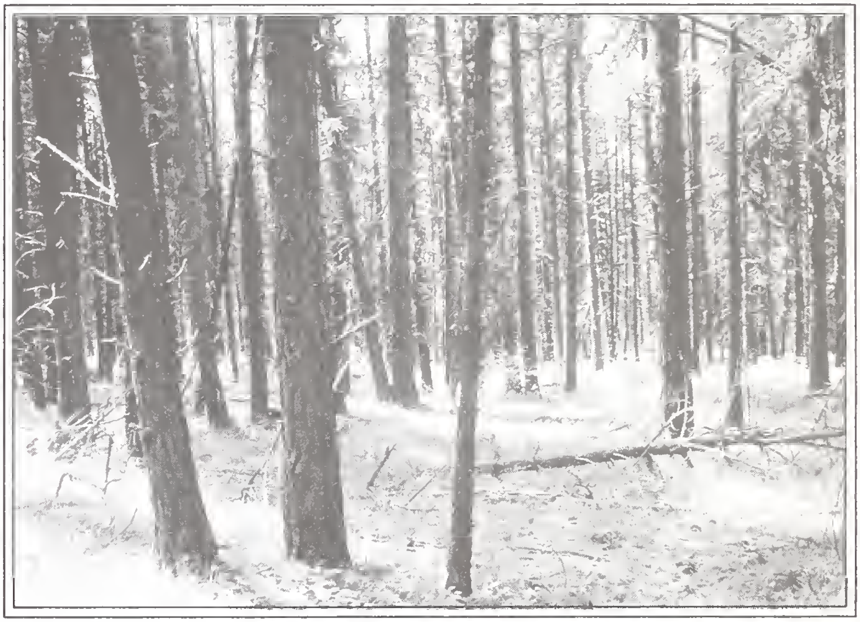
by Joe Scott and Rick Fletcher, Rocky Mountain Research Station

Ponderosa pine is the most dominant forest type in the western U.S., occupying nearly 40 million acres. On roughly half of these acres, the tree is a climax species, forming pure stands. Because fire has been largely excluded from these stands, forests have become overstocked and dense with seedlings and saplings. As a result, these forests are highly flammable. While fires of past centuries were characteristically of low intensity and severity due to their high frequency, today's fires, when they do occur, exhibit high intensity, often resulting in crown fires.

These forests are not only the most extensive and most altered by fire exclusion, but also one of the most used for residential and recreational development—highly valued for their scenic quality and proximity to urban centers.

Land managers have long understood that fire hazard in ponderosa pine forests can be lessened by prescribed burning, removing understory fuels, pruning lower branches, and thinning. But when such treatments are proposed for residential or recreation areas, their effects on visual quality come into play. Many homeowners are aware of the need to manage fuels on their forest properties, but often fail to act because of concerns about the cost of reducing fuels and the negative effects on aesthetics.

Results of a fuel reduction study, supported in part by the Rocky Mountain Research Station, and conducted on the Lolo National Forest in Montana, have just been published. The study looked at



Three thinning treatments were applied to this ponderosa pine forest.

three different treatments designed to (1) reduce crown fuels and thereby fire hazard, (2) provide revenue to offset thinning costs, and (3) maintain the aesthetic appearance following treatment. Joe H. Scott, a forester specializing in fuel treatments for the wildland and urban interface, and working under a contract agreement with the Rocky Mountain Research Station, designed the study. "To effectively manage visually sensitive ponderosa pine forests," says Scott, "Forest Service managers and wildland homeowners need basic descriptive information and a demonstration of example thinning treatments to reduce fire hazard. This study was designed to provide such a demonstration and document outcomes."


Minimum impact treatment.

Study Area

The treatments took place in the Sixmile Creek drainage on the Lolo National Forest, about 20 miles northwest of Missoula, Montana. The area is covered by a dense stand of second-growth ponderosa pine and interior Douglas-fir. The overstory is 95 to 100 years old. The gentle slopes (5 to 20 percent) are generally south-facing, at an elevation of about 4,000 feet. The stands are even-aged and relatively even-sized — average diameter at breast height is approximately 10 inches. Understory vegetation is mainly grasses.

Treatments

The treatments were classified into three contrasting "themes": (1) minimum impact, (2) revenue production, and (3) forest restoration. Four 6-acre units were established, one for each treatment, plus an untreated control. Commercial thinning was used to offset treatment costs. To assess visual quality, color photos were taken at representative locations in each unit during the third growing season following treatment. A total of 28 viewers were shown 10 sets of photos. A few viewers had education or experience in natural resource management, but most were laypeople.

The **minimum impact treatment** was thinned from below. Trees were hand-felled, limbed and bucked into logs, then skidded to a roadside deck using a modified farm tractor with logging winch. Slash, some understory conifers, and jackpots of existing fuels were burned in small hand-built piles.

The **revenue production treatment** was thinned from above. The plot was harvested using fully-mechanized tree-length logging using a track-mounted feller-buncher, rubber-tired grapple skidder, and slide-boom delimber. Slash was burned in one large landing pile. No further treatment took place in the unit.

The **forest restoration treatment** was thinned from below. Harvest method was the same as in the revenue production treatment, but most of the slash was "back-hauled" and distributed over the unit with the grapple skidder. The unit was then broadcast burned in the fall under mild weather conditions.

Revenue production treatment.

Results

"All of the treatments developed in this study are appropriate for reducing fire hazard in an aesthetically pleasing and cost-feasible manner," says Scott. "Although the treatments are similar in design and implementation, there are differences among the treatments, both obvious and subtle, which make them appropriate in different situations," he says. Following are results of this study:

Minimum Impact Treatment

Scott says this treatment is favored for its aesthetic preference, being preferred over not only the other treatments, but over the untreated stand as well. He believes the aesthetic acceptance of this treatment probably results from the nature of the thinning (from below) and the low-impact logging and slash disposal methods. "The treatment was moderately effective in reducing fire hazard by reducing fine fuels, raising the lower crown base height, removing ladder fuels, and spacing tree crowns," he says. Although this treatment produced less net income than the others, it nontheless more than paid for itself, providing a return of $156 per acre to the landowner. "This treatment is well-suited for small private residential properties where aesthetic values are high. This approach may also be useful as an initial thinning treatment that could be followed in a few years by additional thinning to enhance tree health. Such a two-stage treatment might also reduce wind or snow damage and make the transition to an open stand more gradual and acceptable to the public. The Forest Service and other land management agencies may find such a treatment useful in areas with high recreational values where there is public concern over harvest impacts," says Scott.

Without further treatment, this stand will eventually redevelop a Douglas-fir understory. To maintain the open structure, retreatment should be considered on a 10 to 20 year cycle.

Revenue Production Treatment

This treatment produced more immediate-term income than the other treatments ($832 per acre), was effective at reducing fire hazard by reducing crown fuel, and ranked high in visual preference. This type of treatment would be appropriate on a wide range of public and private lands.

"Over time, this stand will redevelop a conifer understory," explained Scott. "Douglas-fir will dominate the understory, but successful regeneration of ponderosa pine is possible in the larger openings within the stand. Crown fuels should remain low for several decades, until the understory grows into the overstory crown space. Surface fuel loadings will remain low because of the reduced input of litter, and because little mortality is expected in the vigorous overstory. Retreatment of this stand should not be necessary for 20 to 30 years," he said.

Forest Restoration Treatment

This treatment represents a unique ecological restoration emphasis that balances aesthetics, income production, and forest health — "an 'ecosystem management' treatment with broad applicability," says Scott. It was the most effective in reducing fire hazard. Even with the higher cost of the broadcast burn, this treatment showed a

Forest restoration treatment.

modest return of $222 per acre. Scott believes that burning would be more economical when applied to larger units. "While aesthetic quality suffers for a few years whenever a broadcast burn chars the boles of trees, periodic application of this treatment would lead to an open-structured forest of large trees, which has high aesthetic value. This type of thinning and burning treatment has broad applicability on public and increasingly on private lands in the pine type," he said.

Retreatment of this stand should be considered at 15 to 20 year intervals, with future treatments aimed at reducing basal area enough to encourage successful ponderosa pine regeneration.

Scott believes that as land managers move toward landscape-level implementation, these treatments should be used first in the places where they can be expected to have the most benefit — the wildland/urban interface. "There are high property and amenity values requiring protection from wildfire," he says. "The public recognizes this need and generally supports ecosystem restoration treatments in these areas, and an established road system will keep costs and controversy to a minimum. Managers may be able to increase the scope of application on the landscape as their experience in applying these treatments grows. Increasing the scope should reduce the cost of implementing these treatments, especially those involving the use of fire."

Further details of this study are available in *Fuel Reduction in Residential and Scenic Forests: a Comparison of Three Treatments in a Western Montana Ponderosa Pine Stand*, Research Paper RMRS-5, by Joe H. Scott. The paper is available from the Rocky Mountain Research Station while supplies last.

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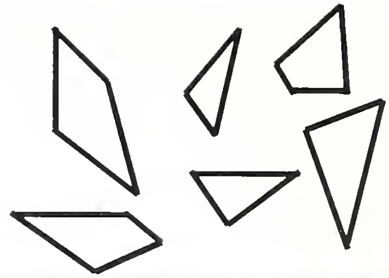
Puzzles, Big Pictures, and Macroscopes



by Dave Tippets,
Rocky Mountain
Research Station

My youngest boy, Joshua, loves jigsaw puzzles. For years he always specified a certain jigsaw puzzle on his Christmas wish list. With every passing year he desired a larger and more complex puzzle. From a young age he amazed his mother and I with his ability to stay focused for long periods on the puzzle until he completed it.

Assembling pieces of the puzzle into a complete picture or structure brought him joy more than once. When he first solved the puzzle he'd almost immediately take it apart and store it in his closet. Then, month's later he'd remember that is was there, drag it out, and solve the puzzle all over again.

One day, while he was experiencing a temporary fit of boredom that was breeding contention with his brother, I remember that he had solved his last Christmas puzzle only once.

"Joshua," I called, in an attempt to return tranquility to our home, "why don't you work on that dimensional jigsaw puzzle?"

"It's ruined," he yelled back with intensifying hostility, "my brother lost some of the pieces."

"So, just put it together without those pieces," I replied, still hoping to distract him from the rapidly escalating war with his brother.

"Duh!" He exclaimed incredulously, "why would anyone want to solve a puzzle when they know that they don't have all the pieces."

Now, a few years later, Joshua's favorite games have evolved from simple jigsaw puzzles through more complex computer-based puzzles such as Myst and Riven. As a high school freshman, he has two summers at Northwestern University studying chemistry and computer science already behind him. The joy he finds in solving puzzles has been enthusiastically transferred to math and science. He now searches to discover pieces of puzzles that he has never seen, and which he must find before completing the puzzle.

Somewhere along the path of his personal growth, I missed recognizing the point where he no longer expected others to provide him with all the pieces of the puzzle, and he learned that searching for and discovering pieces of the puzzle were more rewarding than just having everything handed to him in a box. At some point Joshua stopped needing to have the big picture on the cover of the puzzle box, and he learned how to proceed with solving puzzles based on just an idea, a hypothesis, or a theory to guide him.

There has been another leap in Joshua's growth. He now accepts responsibility of saving all the pieces of the puzzle once he finds them. He finds it instinctive to share and explain each new piece of a puzzle that he discovers to others in his peer group. Last Christmas we were all kept informed in progress at solving Riven, because each time a new piece of the puzzle fell into place he summoned an audience to witness his success — explaining how and why he'd progressed to the next level.

His love of solving puzzles convinces us that in the future Joshua may very well solve one or more of the world's great problems.

As I contemplate the various artifacts of almost 100 years of research at the Forest Service's Rocky Mountain Research Station, I realize that most of those artifacts are pieces of puzzles. Some of the pieces are represented as government reports, some peer-reviewed journal articles, some data bases on CD-ROM's, and some puzzle pieces are even information on Internet web sites. No matter what their form or age — the artifacts of our organization's history are pieces of puzzles.

Getting the Big Picture

When we have been lucky, scientists have gotten all the pieces to complete a given puzzle; have put all the pieces together; and then, like Joshua's early jig saw puzzles, the assembled pieces have formed a big picture. But many ecosystem and natural process puzzles are not yet completed — they are still missing needed parts, waiting for scientists to find all the pieces and put them together so the rest of us can get the big picture formed by the completed puzzle.

The microscope may be the most recognized icon of science. It symbolizes the quest to find and describe smaller and smaller pieces of information as scientists probe deeper and deeper into the unknown. Each year scientists working at and with the Rocky Mountain Research Station produce over 800 technical reports. Some of them represent knowledge that can be seen by the naked eye, and which most of us can see the big picture into which those pieces of the puzzle fit.

Things get pretty exciting when we think we have a puzzle almost complete and can start to see the big picture. For example, we are starting to get a more complete picture of what healthy riparian and aquatic ecosystems look like. We can place those components in landscape- scale watersheds and start to understand the relationship between the upslope parts of the watershed and stream channels. So when Mark Smelser and John Schmidt of Utah State University recently completed General Technical Report RMRS-6, *An Assessment of Methodology for Determining Historical Changes in Mountain Streams*, we could stand back, look back at the big picture and see they had provided a tool that would help natural resource managers restore damaged watersheds.

Then when a diverse team of researchers and a land manager recently collaborated to create the Field Guide to Intermountain Sedges, General Technical Report RMRS -10, land managers had another tool to help them reassemble the pieces of a disturbed watershed and create a new healthier system of land and water. Sedges are often critical to bind streambanks together and stabilize them against the force of moving water. Sedges are puzzle pieces in a healthy watershed. Species of sedges are often difficult to tell apart. Different species play different roles. This report is a tool that will make it much easier for natural resource managers to identify sedges so they can tell which puzzle pieces they have to restore healthy watersheds.

The distinguishing floral parts of sedges are puzzle pieces that often had to be discovered and described with a microscope. Other puzzle parts can't even be seen with microscopes and have to be described with mathematical models. Most of us struggle to see the part of the our world that microscopic or mathematically described puzzle pieces help us understand. Even though just small pieces of a puzzle, scientist excitedly describe them and share them with other scientists working on the same puzzle. To save them so they won't be lost, scientists thoroughly describe them in publications and explain to other scientists how they then found them. The tiny, complex, and intricate puzzle pieces are often difficult for most of us to see in the big picture. Often, only the scientists working with them can see how they fit together.

I remember Joshua lying down in the floor by his jigsaw puzzle, inviting others to join him to help solve the puzzle faster than he could working by himself. I see that as the boy grows into a man, the basic emotions will remain the same while the methods and procedures for sharing information grow more sophisticated. After little boys and little girls grow into adult scientists they often conspire with their peers around the world to share their pieces of the puzzle so that they can assemble it faster by working together. Instead of simply just flopping belly down on the floor together, they meet in symposiums and conferences to share the pieces of the puzzles that they've discovered.

The Future of Arid Grasslands: Identifying Issues, Seeking Solutions, Proceedings RMRS-3, is a good example of adult collaboration to solve a puzzle. Researchers from Colorado, Arizona, New Mexico, and Mexico assembled in Tucson in October of 1996 to look at an arid grassland puzzle that had enough pieces in place that generalists could see the picture with their naked eye. Public land managers and ranchers

joined the scientists to collaborate on the stewardship of arid grasslands, and figure out how to finish putting the last pieces of the puzzle together. When they finished, they saved the pieces of the puzzle in a 392 page compilation, went their separate ways, and some are still working to finish the puzzle.

Often in the final stages, after scientists have identified and described all the necessary pieces of the puzzle, the job of how to put the finishing pieces together is left to natural resource managers and policy makers. At the point of the completion, the decisions are, as former Forest Chief Jack Ward Thomas said, "moral not technical," because the final decisions will be based on values, rather than technical information. For example, in the Columbia River Basin scientists have provided the information needed so that the puzzle can be put together so that the big picture can include ocean-going Pacific salmon. Whether or not in the end the big picture will include salmon will be a decision based on values. Scientists gave managers and policy makers the pieces of the puzzle — now they must involve the public and decide if salmon will remain in the picture.

Looking through a Macroscope

I am one of a comparatively small number within a research organization who spend their time looking through a macroscope. Scientists discover, describe, and publish the pieces of their puzzles then send them through my office so that I can examine them. Through my macroscope I study the artifacts of RMRS's research to see how they fit into the bigger picture of the Forest Service's mission.

My macroscope is constructed on a foundation of personal education and experience, and aided by frequent consultation with RMRS scientists. Dedicated to being a generalist, I went the opposite direction from scientists for my second college degree and instead of looking deeper into the ecosystem I studied ecosystems through the horizontal perspective of a macroscope.

Now a macroscope often has serious limitations mind you. For example, when Research Paper RMRS-6, *Weighted Linear Regression Using D2H and D2 as the Independent Variables*, came across my desk today, I examined it through my macroscope and no matter how many times I tried to focus my macroscope, I just couldn't get a clear picture of that puzzle piece. The authors gave me a clue; foresters will be able to better estimate the volume of loblolly pine. Then I saw the problem; I had a western qualitative macroscope when a southern quantitative macroscope was needed.

Then Research Paper RMRS-5, *Fuel Reduction in Residential and Scenic Forests: a Comparison of Three Treatments in a Western Montana Ponderosa Pine Stand*, appeared in my inbox. I looked at it through my macroscope and it immediately came into focus. I could see how that piece of the puzzle fit into it's ecosystem. In this case, I was lucky that the author Joe Scott and fire ecologist Steve Arno had taken me into the woods and helped me calibrate my macroscope to view fire in ponderosa pine communities.

My luck held when General Technical Report RMRS-14, *Plant Herbivore Interactions in Atriplex: Current State of Knowledge*, surfaced for me to look at. My college professors in range science and Station scientists at the Provo Shrub Sciences Laboratory had taken me on many trips into Utah's West Desert rangelands. My macroscope was calibrated and ready. I saw saltbrush defending itself against overbrowsing by cattle and sheep.

Again my luck held when *A Management-Oriented Classification of Pinyon-Juniper Woodlands of the Great Basin*, General Technical Report RMRS -12 surfaced in my inbox. My macroscope was tuned for this one. Professor Neil West had refused to let me graduate from Utah State until I understood a little about arid-land ecosystems, and then more recently his collaborator Robin Tausch had taken me into the Great Basin and taught me about some their more recent discoveries in Great Basin woodlands.

Even with these occasional successful uses of my macroscope, I can see trouble looming on the horizon. The future appears clearly before my eyes. I can see Joshua home for Christmas vacation from MIT. I know that he won't invite me to flop down beside him on the floor to help him solve his puzzles. He will have little use for my macroscope. Just as the rest of us once were, he will for a few years be intoxicated with the quantity and quality of his own knowledge.

Then, chances are, life will gradually sober him. He will realize that few can understand the significance of his contribution to society. Few will be able to put his work into the big picture. Suddenly, he will want others to appreciate what he's learned, and he will go in search of a generalist with a macroscope. By then, my macroscope will be rusty and obsolete. But with luck, I won't care, because I'll be gone fishing for salmon on the headwaters of the Columbia.

Soil...

Foundation for the Ecosystem

by Robert F. Powers,
Gary O. Fiddler
and Connie R. Gill,
Pacific Southwest Research
Station

Much of a site's fertility is in the forest floor.

Soil is a fundamental ecosystem property for setting the productive potential of a site for myriad values. Climate and solar energy also affect these values but, unlike these, the soil's productivity can be affected directly by management. If the soil's ability to supply air, water and nutrients to plant roots has been changed, then its ability to grow forest vegetation has also changed.

Land productivity is defined by the Forest Service as the "capacity of a given site to sustain plant growth." This capacity provides the underpinning of ecosystem health and sustainability. A loss of that capacity spells the loss of other resource values as well.

To help protect the land's productivity capacity, the Forest Service is monitoring the impact of forest management practices on soil. A North American Long-Term Soil Productivity research program (LTSP) was established in 1989 between the research and management branches of the USDA Forest Service, and has expanded to partnerships with Canada. The impetus for this was the National Forest Management Act of 1976 which requires that National Forest lands be managed in ways that will not impair their long-term productivity (USDA Forest Service 1983). This raises key questions: Is the productive capacity of federal lands declining? If so, why and what can be done? After reviewing the world's literature on productivity decline, a select group of scientists concluded that soil porosity and site organic matter are the key properties most influenced by management and most related to forest health and growth within the constraints of climate and topography (Powers et al. 1990). Figure 1 (page 19) illustrates the concept.

The LTSP program is based on the following principles:

- Within the constraints set by climate and relief, the productive potential of a unit of land depends on soil resources.
- Management practices cause soil disturbances affecting soil properties and processes. In turn, these processes govern potential productivity.
- The main soil processes controlling potential productivity involve physical, chemical, and biological interactions affected by soil porosity and site organic matter.

Early in the study, standardized treatments were chosen that could be applied across a broad range of soil types and climates. These treatments create gradients in soil porosity and site organic matter following a harvest, and produce a range of stress conditions from minimal to extreme. These stress conditions include the kinds of management disturbances that are likely now or in the future. The treatment design allows for the development of response surfaces describing productivity as influenced by various combinations of disturbance.

The study is long-term and addresses the following questions:

- What is the productive capacity of a given forest site?
- How is this affected by changes in soil porosity and site organic matter?
- What are the underlying processes?
- Do impacts vary by soil type and climate?
- How long do the effects last?
- Are there operationally effective indicators?
- If impacts are detrimental, can they be mitigated?

Methods

The LTSP program follows a standardized format with some modification for local conditions. Steps include site selection, pretreatment measurements, treatment installation, and post treatment measurements. Procedures follow.

Experimental Design

Site Selection. Major soil types are identified across a site quality gradient from low to high within a major forest type and climatic region. In California, this is the mixed-conifer forest type of the Sierra Nevada and Cascade Mountains. Sites must be timbered with young, mature stands that include the soil of interest. Prospective sites are then examined for stand condition (proper soil and cover type, closed canopy), area, degree of surface disturbance, and any administrative restrictions on land use.

Next, temporary treatment plots of 0.4 ha (1 acre) are established, gridded, and mapped for soil and stand variation. Mapped data are examined for patterns of spatial variation. Plots showing similar patterns of variability are accepted for the LTSP study. Timber sale and reforestation contracts are advertised by each Forest and awarded through the normal bidding process.

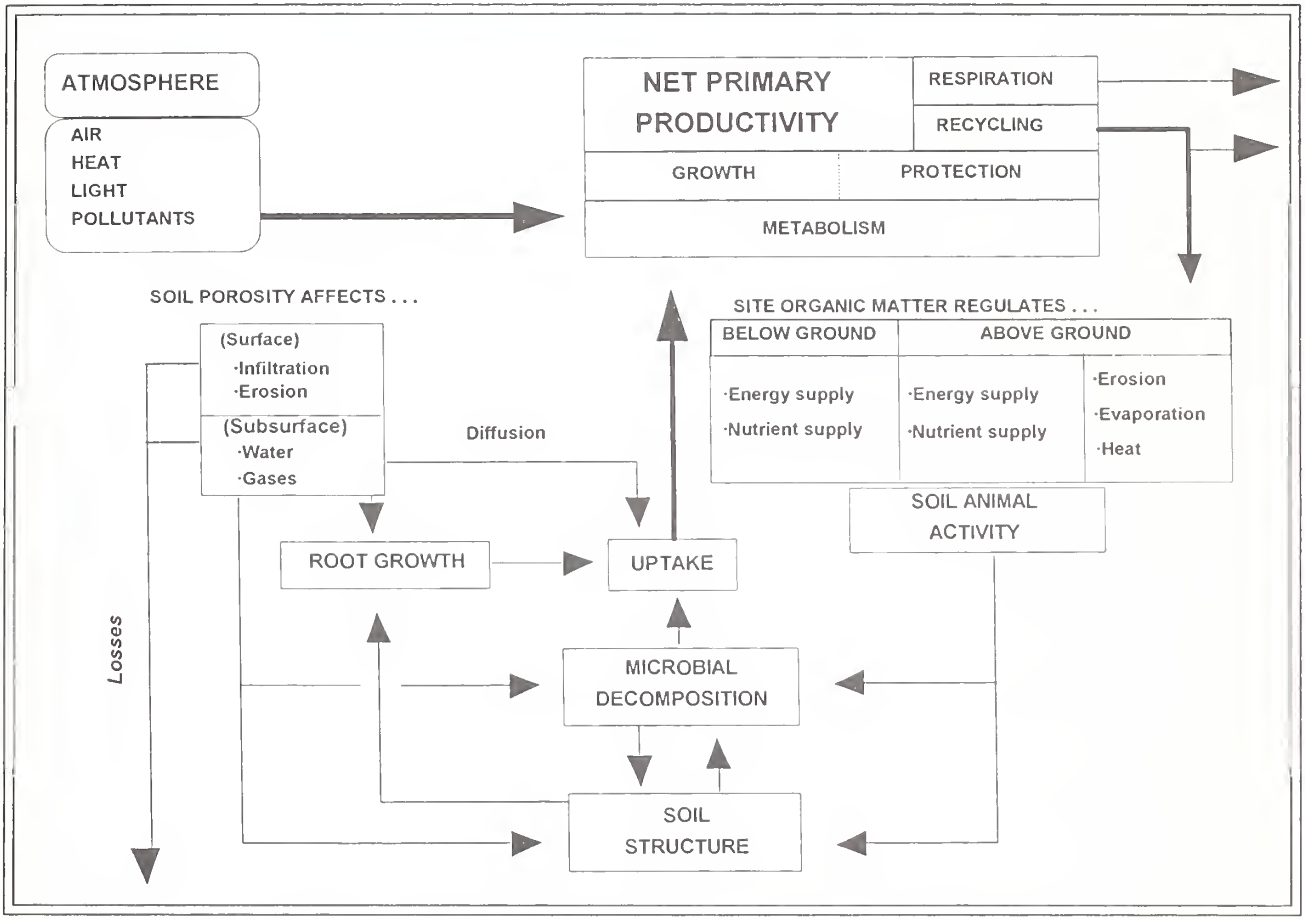


Figure 1: *Soil porosity and site organic matter affect sustained productivity through their control of major site processes. Understanding what happens when soil porosity and site organic matter are altered is an important goal of the LTSP effort.*

Pretreatment Measurements. All living trees are measured for diameter at breast height (dbh) by species. Thirty to 40 trees are chosen for pretreatment measurements, felled and measured at varying positions from stump to the top of the tree. Disks are sawn and branches are removed to determine biomass and nutrient content. Mathematical functions are developed to estimate bole and crown mass and nutrient content as a function of dbh. This allows for estimating the biomass and nutrient content of standing trees, and for estimating the quantities removed or retained in the various treatments.

Ground vegetation is sampled at random points in each treatment plot. Woody and herbaceous plants are collected for biomass and nutrient analysis along with coarse and fine forest floor materials. Finally, samples of mineral soil are collected for bulk density and nutrient analysis.

Treatments. Nine LTSP core treatments are assigned randomly to the plots. These consist of three levels of organic matter removal crossed with three levels of compaction:

Organic Matter Removal	Soil Compaction
Stems and Slash Retained	No Compaction
All Living Vegetation Removed/ Forest Floor Retained	Intermediate Compaction
All Organic Material Removed/ Mineral Soil Exposed	Severe Compaction

From these treatments, nine possible combinations result as shown in figure 2 (page 22). Other mitigative treatments such as subsoiling and fertilization are included at many sites. The experiment is replicated on the same and contrasting soil types at differing geographic locations throughout the range of the forest cover type. Effects will be analyzed statistically by analysis of variance among sites of similar or contrasting soil type, and by regression using soil and climatic variables linking one site to another.

Trees and vegetation are removed by a variety of means to avoid soil disturbance. The complete organic removal treatment is "low tech." The forest floor is raked by hand onto tarps and carried from the plots. Compaction is applied by multiple passes with a self-propelled, vibrating drum in the spring when soil moisture is near field capacity and strength is low. When certain combination treatments like stem only and whole-tree removals with moderate and severe soil compaction are performed, surface residues are removed before compaction and then returned to the plot. Each treatment plot is regenerated with tree species of the natural forest type (four species of conifers in California). All planting holes are dug with gasoline-powered augers. This may not be necessary on noncompacted soil, but it prevents early mortality in compacted soil. Trees are protected from mammal damage by fencing and/or Vexar tubing, as needed.

Procedures Following Establishment

Vegetation Control. By the third year, competing vegetation is eliminated chemically or mechanically on one-half of each 0.4 ha treatment plot. This establishes subplots of contrasting plant communities: (1) a simple community consisting merely of trees on one half; and (2) a diverse community of trees, shrubs and herbaceous vegetation on the other. Vegetation control treatments are reapplied as often as needed to establish a tree-only condition on nine subplots.

Advantages of these side-by-side, contrasting treatments with and without vegetation control include:

- Net primary productivity (NPP) can be measured in a restricted sense when all site resources focus on a simple community of trees requiring the same resources at about the same degree.
- Net primary productivity can be measured in a more complete sense when resources are distributed among a complex plant community using different levels of resources at different degrees.

Sustained productivity depends on chemical, physical, and biological conditions of the soil.

- This design permits studying the long-term significance of simple and complex plant communities on soil properties affecting a site's productive potential.
- Such designs can answer questions of how changes in soil porosity, site organic matter, and early secondary succession affect forest biodiversity at maturity.
- The design can test the significance of understory vegetation on tree growth under varying degrees of site disturbance.
- This study will answer how understory vegetation affects erosion and soil recovery rates during early stages of stand development.

ORGANIC MATTER REMOVAL

COMPACTION	Stem Only	Whole-Tree	Whole-Tree+ Forest Floor
None	SO None	WT None	WT+FF None
Medium	SO Medium	WT Medium	WT+FF Medium
Severe	SO Severe	WT Severe	WT+FF Severe

Other Treatments	Mitigation	Operational

Figure 2: *Standardized experimental design for LTSP treatments showing all possible combinations of organic matter removal and soil compaction. Following regeneration, each 0.4 ha treatment plot has vegetation controlled on one half of the plot (trees only). The other half receives no vegetation control (trees plus regional vegetation).*

Post Treatment Measurements

Measurements that must be made at specific intervals following stand establishment include:

Variable	Measurement Interval
Climatic data	Continuously
Soil moisture and temperature	Monthly
Soil bulk density and porosity	Soon after treatment and each 5 years
Soil strength	Seasonally each 5 years
Water infiltration rate	Each 5 years
Plant survival, growth	Years 3, 5, and each 5 years
Plant net primary productivity	Each 5 years
Soil chemistry	Each 5 years
Plant chemistry	Each 5 years

Progress to Date

Thirty-nine LTSP installations currently are operational in the United States, and another three are in early establishment stages in central Idaho. The BC Ministry of Forests installed six others in interior British Columbia and the Canadian Forest Service has several in Ontario. In all, about four dozen common-protocol installations will be in existence by the end of 1998. Of these, 12 have been established in California: 11 on national forests, and one at Blodgett Research Forest (managed by the University of California).

Results/Summary

The LTSP experiment is chartered to last at least one full rotation, and the oldest installations are just reaching crown closure. Crown closure is an important event because it marks the earliest date for a reasonable indication of long-term trends. Early findings illustrate the significance of competing vegetation in masking the true effect of soil compaction and organic matter removal on tree growth.

Among the most important findings to date are those concerning the effects of treatment on soil physical properties affecting site productivity. One such finding concerns surface organic residues. Retaining the forest floor or logging slash has an immediate impact by keeping soils cooler in the summer and improving plant water availability by reducing evaporation. This mulch effect may not be as beneficial in colder and wetter forest regions. A second immediate benefit of organic surface residue is its clear role in reducing soil erosion. Ultimately, these residues release nitrogen, phosphorus, and other nutrients for plant uptake. This is particularly important on sandy soils low in organic matter.

Another important finding concerns the emergence of soil strength measurements as a useful monitoring technique. Compacted soils reach growth-limiting strengths early in the potential growing season. Competing vegetation exacerbates the problem by drying the soil faster, thereby increasing the normal rate of rise in soil strength. Perhaps the final important finding is that a slight amount of compaction may improve the available water holding capacities of coarse-textured, sandy soils. In dry climates, the significance of this can be seen in improved plant growth.

In conclusion, the results are preliminary. Sweeping generalizations are risky under any circumstances—and particularly so when they are based on scattered results from a few young plantations. The long-term value of the LTSP experiment is self-evident, but early results should be judged with caution.

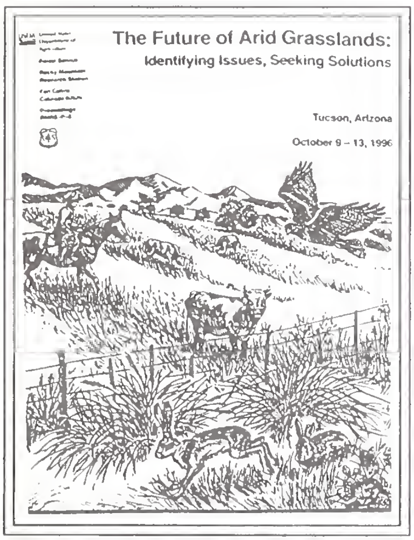
Measuring the mass and nutrient content of entire trees.

For more information on this study contact: Robert F. Powers, Pacific Southwest Research Station, 2400 Washington Avenue, Redding, CA 96001, 530-242-2450.

New from Research!!!

The Future of Arid Grasslands

Proceedings from the Future of Arid Grasslands conference, held in Tucson, Arizona in 1996, have now been published. The conference was designed to provide a non-confrontational setting for a variety of people from differing viewpoints to discuss the threats facing arid grasslands of the Southwest. Participants included ranchers and other private economists, scientists, and students. The sessions were organized around the major themes of understanding grasslands, identifying grassland issues, managing grasslands, and seeking solutions to grassland issues. Many of the sessions were in the form of panel discussions or informal presentations. Copies of *The Future of Arid Grasslands: Identifying Issues, Seeking Solutions*, are available from the Rocky Mountain Research Station while supplies last. Request Proceeding-RMRS-5.



Fire Behavior in the Tragic 1994 South Canyon Fire

Fire investigators at the Intermountain Fire Sciences Laboratory and Missoula Technology Development Center in Missoula, MT, recently completed the most detailed and in-depth analysis of the fire behavior of the 1994 South Canyon Fire in Colorado that killed 14 firefighters.

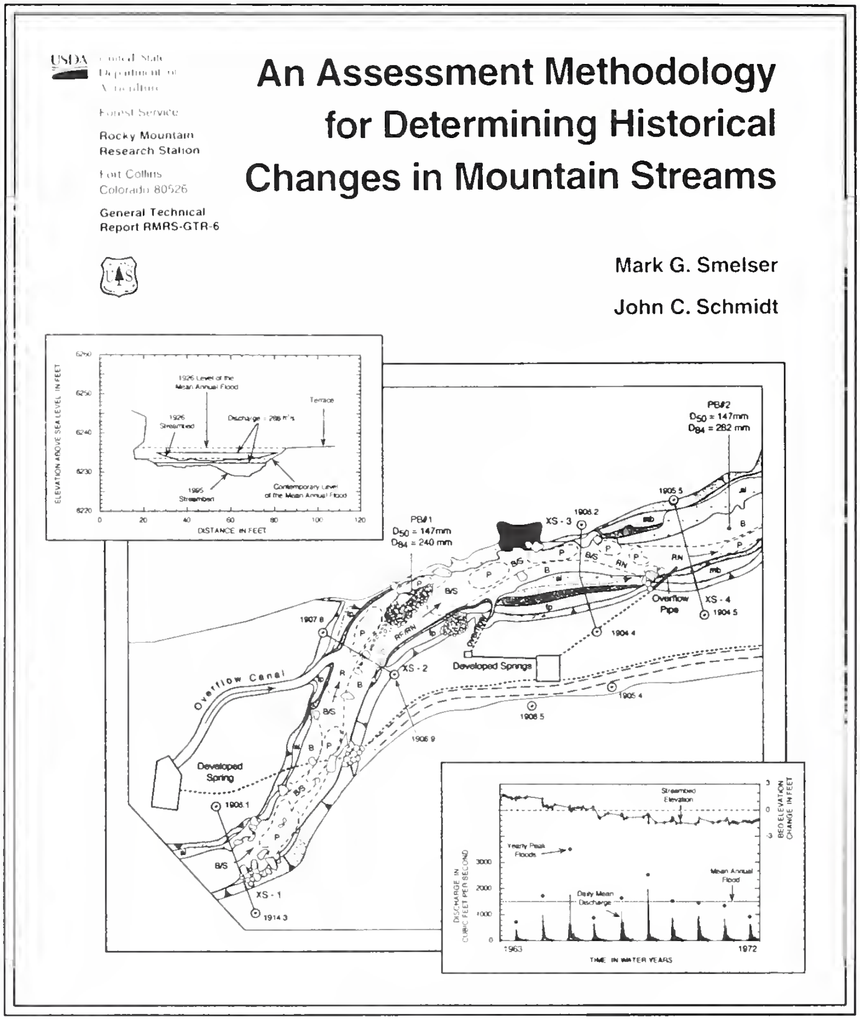
Immediately following the tragic accident, a timely investigation was completed that answered many of the important questions related to the fire and entrapment of the firefighters who died. However, some questions related to the fire's behavior remained. Given much more time to complete a scientific analysis of the fire's behavior, the seven-person team from Missoula made every possible effort to learn and explain the scientific phenomenon of the blowup that occurred on Storm King Mountain on July 6, 1994.

The teams intensive and extensive analysis confirms several things already known about the behavior of wildfires in mountainous terrain. There were no new startling discoveries, only reinforcement of principles before thought important for firefighters to understand. This research paper will serve as a teaching tool to help firefighters even better understand just how important those principles of fire behavior are, and in doing so, will contribute to firefighter safety.

Request *Fire Behavior Associated with the 1994 South Canyon Fire on Storm King Mountain, Colorado*, Research Paper RMRS-9, from the Rocky Mountain Research Station. Supplies are limited.

Historical Changes in Mountain Streams

Successful management of water in mountain streams by the USDA Forest Service requires that the link between resource development and channel change be documented and quantified. The characteristics of that linkage are unclear in mountain streams, and the adjustability of these streams to land-use and hydrologic change has been argued in court. One way to quantify the adjustability is to examine its geomorphic history. An excellent source of historic geomorphic data are the records associated with stream gaging stations maintained by the U.S. Geological Survey. This report describes what records are available, how to organize the data on computer spreadsheets, and discusses 6 techniques that quantify the spatial and temporal magnitude of historic channel adjustments. For your copy, write the Rocky Mountain Station and request *An Assessment Methodology for Determining Historical Changes in Mountain Streams*, General Technical Report RMRS-6. Supplies are limited.



Field Guide to Intermountain Sedges

A new spiral-bound field guide to sedges is made to be packed along the West's mountain streams to assist field-going hydrologists, botanists, range technicians, wildlife biologists, and others in identifiy the taxonomically challenging members of the carex family of plants. It is often one of the most challenging kinds of plants to identify in riparian zones — but plants often critical to maintaining healthy and stable streambanks.

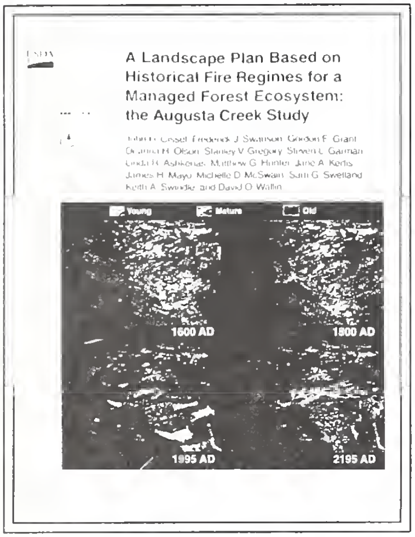
The guide is colorfully illustrated with photographs of sedges and their floral parts that are critical to species identification. The book is small enough to fit in a jacket pocket. It's durable enough to withstand more than one rainstorm, accidental contamination, mosquito repellent, and other kinds of field abuse. If you work to conserve healthy and stable watersheds in the West, you need this book nestled along side your plant key.

Request *Guide to Intermountain Sedges*, General Technical Report RMRS-10, from the Rocky Mountain Research Station, and if you don't already have it, also request *Field Guide to Intermountain Rushes*, General Technical Report INT-306. Supplies are limited.

Evaluating Resources on the Beaver Creek Watershed

The Beaver Creek Experimental Watershed, located in north-central Arizona, was established in 1956 in response to public concerns that the flow of streams and the amount of livestock forage on watersheds in the Salt-Verde River Basins were being reduced by increasing densities of ponderosa pine saplings and pinyon-juniper trees. This new report covers the natural resource responses to the manipulation of ponderosa pine forests by various silvicultural treatments and by conversion techniques of pinyon-juniper woodlands to herbaceous covers. Study results show that changes in vegetation cover can produce short-term changes in streamflow from the ponderosa pine type, and limited amounts from a herbicide treatment of pinyon-juniper. Vegetation modifications on upstream watersheds can be designed to provide forage, wildlife, timber, and amenity values required by society in some optimal combination. The implications of results from these studies are not confined to the Southwest, but are of national and international interest. Details are in the report *Multiple Resource Evaluations on the Beaver Creek Watershed: An Annotated Bibliography (1956-1996),* General Technical Report RMRS-13. Copies are available, while supplies last, from the Rocky Mountain Research Station.

Planning Based on Fire Regimes



The Augusta Creek Study was designed to establish and integrate landscape and watershed management within a 19,000-acre planning area in the central Cascade Range of Oregon. The study team, led by John H. Cissel, research coordinator for the Cascade Center for Ecosystem Management, developed management prescriptions based on the historical range of variability of landscape conditions and disturbances in an area primarily devoted to timber harvesting.

Using a variety of techniques, the research team documented a 500-year history of fire in the area, charted landslide and debris-flow events, and examined the impacts of past and present uses of the area. They created maps displaying projected landscape conditions by using the plan they developed and made comparisons of expected future conditions based on management activities prescribed under the Northwest Forest Plan.

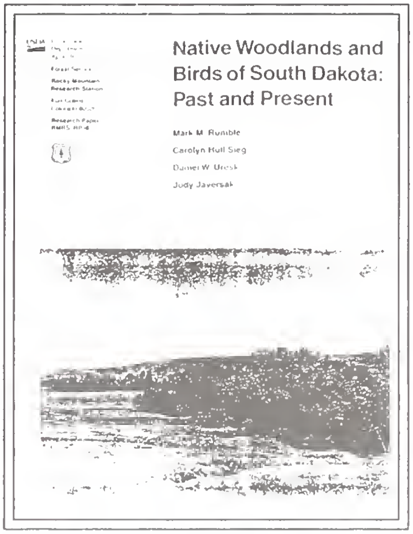
This report demonstrates how timber harvest activities and managed fire may be used to maintain some of the effects of natural, unmanaged fire in a forest ecosystem. In addition, it indicates that further studies of the effects of fire exclusion are needed. The authors suggest that the techniques they developed for their landscape plan may be useful in making specific improvements in Northwest Forest Plan implementation.

Request *A Landscape Plan Based on Historical Fire Regimes for a Managed Forest Ecosystem: the Augusta Creek Study*, General Technical Report PNW-422, from the Pacific Northwest Research Station. Supplies are limited.

Native Woodlands and Birds of South Dakota: Past and Present

Nature appears to be full of contradictions — natural oxymorons — so to speak. Take for example "prairie woodland." Yet native woodlands along rivers and drainage ways in the Great Plains have in the past, and still today, provide critical habitat for a high percentage of birds native to the Great Plains. There are many new species of birds in the Great Plains that did not live there 150 years ago. Yet, at the same time it has been hypothesized that expanding woodland vegetation jeopardizes the biological integrity of the Great Plains.

Research completed by scientists at the Rocky Mountain Research Station's Center for Great Plains Ecosystems Research in Rapid City, SD, and a collaborator at Colorado State University, shows that the threat to the


Native Woodlands and Birds of South Dakota: Past and Present

Mark M. Rumble

Carolyn Hull Sieg

Daniel W. Uresk

Judy Javersak

natural biodiversity of Great Plains ecosystems comes not from changes in the native woodlands, but rather from increases in the non-native woodlands that have accompanied the spread of modern human development across the Great Plains. These human-dependent woodlands associated with urban development have created migration corridors for an influx of eastern bird species, including the blue jay, common grackle, indigo bunting, and other newcomers to the plains.

The researchers conclude that if the goal is to maintain the native species of birds that were present 150 years ago, land managers need to continue their efforts in restoring and sustaining native woodlands. The new encroaching artificially planted woodlands associated with human development are providing habitat for news species moving in from the East, but will not replace natural native woodlands in providing habitat for the same bird species that occurred at the time of white settlement.

Request *Native Woodlands and Birds of South Dakota: Past and Present*, Research Paper RMRS-8, from the Rocky Mountain Research Station. Supplies are limited.

Salt Brush Defense Against Herbivory

Over 400 species of salt brush grow on some the harshest sites on six continents. Frequently, these plants are among the most desirable browse for both wild and domestic animals. The Atriplex genus also provides some to the most useful plants for reclamation of disturbed lands in arid and saline environments, and on soils with metal toxicity. Unfortunately, these shrubs are often not very resilient to browsing pressure, and land managers need to understand the plant's reactions to browsing in order to maintain the shrubs on the landscape.

This new report summarizes existing knowledge about Atriplex and how this group of plants interact with browsing animals. Request *Plant-herbivore Interactions in Atriplex: Current State of Knowledge*, General Technical Report RMRS-14, from the Rocky Mountain Research Station. Supplies are limited.

H.J. Andrews Experimental Forest

The H. J. Andrews Experimental Forest and Long-Term Ecological Research site celebrated its 50th anniversary in August 1998. To commemorate the establishment of the forest, a bibliography of the research publications produced by scientists working at the Andrews forest over the last decade has been published. The forest, located in the Pacific Northwest Region, is in the Blue River Ranger District, Willamette National Forest.

The bibliography includes technical reports, abstracts, theses, newspaper articles, unpublished reports, and other documents.

Request *Research Publications of the H. J. Andrews Experimental Forest, Cascade Range, Oregon: 1998 Supplement*, General Technical Report PNW-427, from the Pacific Northwest Research Station. Supplies are limited. You also can download the report in PDF format from the Station web site http://www.fs.fed.us/pnw.

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2) *The Future of Arid Grasslands: Identifying Issues, Seeking Solutions*, Proceedings RMRS-5.

3) *An Assessment Methodology for Determining Historical Changes in Mountain Streams*, General Technical Report RMRS-6.

4) *Multiple Resource Evaluations on the Beaver Creek Watershed: An Annotated Bibliography (1956-1996)*, General Technical Report RMRS-13.

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2) *Guide to Intermountain Sedges*, General Technical Report RMRS-10.

3) *Native Woodlands and Birds of South Dakota: Past and Present*, Research Paper RMRS-8.

4) *Plant-herbivore Interactions in Atriplex: Current State of Knowledge*, General Technical Report RMRS-14.

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Oak Woodlands: Ecology, Management, and Urban Interface Issues

How can oak trees compete with the needs and demands of the increasing human population in California and its shift from coastal metropolian areas into formerly rural areas-especially oak woodlands? That was the main question addressed at a symposium on oak woodlands, held in San Luis Obispo, Calif. The technical coordinators for the symposium were Norman H. Pilsbury, Jared Verner, and William D. Tietje.

The proceedings that they put together presents more than 100 papers on subjects related to oak woodlands, which are the predominant vegetation type in the most inhabitable areas of California. Oak woodlands comprise 10 million acres in the State, and have been historically used for livestock production. Today, however, residential intrusion into oak woodlands results in habitat fragmentation and degradation of economic, esthetic, and ecological values. Decision makers and land managers must face up to the pressures caused by the increasing population. People want roads, schools, housing, shopping centers, and water. How can oak trees compete with these needs and demands, and what can the people in charge do about it?

Proceedings of a Symposium on Oak Woodlands: Ecology, Management, and Urban Interface Issues, General Technical Report PSW-160, is available from the Pacific Southwest Research Station (at its distribution center in Fort Collins, Colorado). Supply is limited.

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